ON-LINE MONITORING OF TURBOMACHINERY ALIGNMENT

PROPER ALIGNMENT OF TURBOMACHINERY HAS LONG BEEN RECOGNIZED AS A PREREQUISITE TO SAFE, TROUBLE-FREE OPERATION OF SUCH EQUIPMENT. ON-LINE MONITORING OF ALIGNMENT HAS BEEN DIFFICULT, HOWEVER, FOR LACK OF SIMPLE, RELIABLE TECHNIQUES. THE METHODS PRESENTED HERE ARE HIGHLY EFFECTIVE, YET SIMPLE AND EASY TO IMPLEMENT.

Information for the hot alignment check is normally obtained by measuring vertical and horizontal movements of shafts or bearing housings of turbomachinery components relative to fixed references. When optical alignment techniques are employed, the references are vertical and horizontal planes of sight established by the optical instruments. For electronic or mechanical techniques, the fixed reference is normally the machine foundation. For the typical application, however, the foundation is not in the proximity of the bearing housing, and it is necessary to install pedestals extending from the foundation to a point near the bearing housing, these pedestals becoming the reference from which measurements are taken. To assure the accuracy of the alignment data, the pedestals must be substantial, and they must be maintained at constant temperature to minimize measurement inaccuracies resulting from thermal growth of the pedestals themselves. The pedestals are normally water cooled.

The alternate method presented here also uses the machine foundation as a reference, but eliminates the requirement for alignment pedestals by using permanent reference points which are affixed directly to the foundation and to the bearing housings (or the machine case), as shown in Figure 1. All four reference points lie in a plane perpendicular to the centerline of the machine shaft. Similar reference points are mounted at each bearing housing in the train.

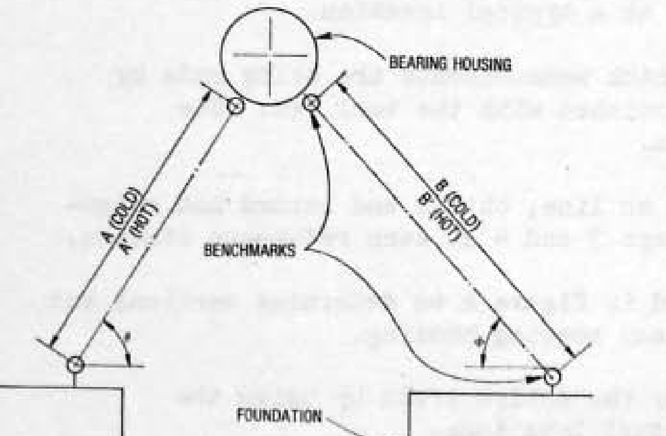

Fig. 1 - Typical placement of benchmarks on foundation and bearing housing.

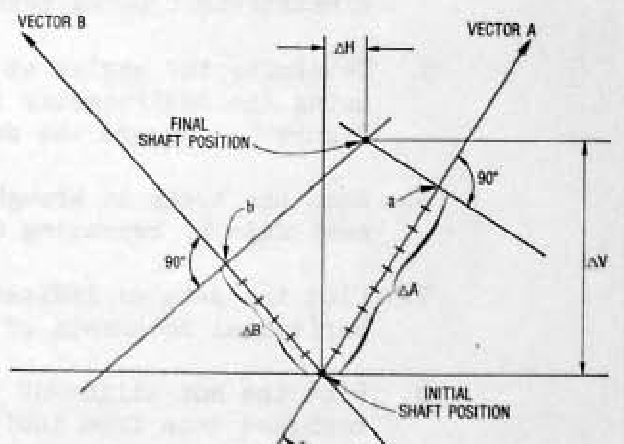

Fig. 2 - Graphical determination of shaft in hot position relative to cold position.

Following cold alignment of the compressor train, reference dimensions A and B, and angles θ and ϕ are determined at each bearing housing, and are recorded. When the machine is brought on line, dimensions A' and B' are measured at each position in the hot running condition. The data thus obtained is adequate for determining the vertical and horizontal movement of each bearing housing in the machine train relative to the foundation. See Figure 2. Using common grid paper (4 x 4 grid is usually a convenient size), lay out reference vectors A and B at angles θ and ϕ, having these vectors cross at one of the grid intersections. The intersection of these vectors represents the centerline of the machine shaft in the cold position. Now refer to the cold and hot measurements previously made (A, A', B, and B'), and determine the movement of the bearing housing along vectors A and B by taking the differences between cold and hot measurements (ΔA and ΔB) for each location. Lay out the movements along vectors A and B using any convenient scale, say 1/4" equals 0.001 inch, to establish points a and b. Now draw lines through a and b perpendicular to vectors A and B. These lines represent arcs of radiuses A' and B' drawn from the foundation benchmarks. The intersection of these lines defines the position of the machine shaft centerline in the hot position relative to the cold position. To determine the movement in vertical and horizontal directions, it is necessary only to scale off the dimensions referred to as ΔH and ΔV, using the same scale as used in plotting ΔA and ΔB. A similar plot for the data secured at each bearing housing affords sufficient information for plotting the hot alignment of the entire turbomachinery train.

A stepwise procedure for alignment by this technique is as follows:

1. Mount the benchmarks on the machine and on the foundation.
2. Align the turbomachinery train in the normal manner. Record coupling alignment data.
3. Calibrate the alignment gauge using the Invar standard, as shown in Figure 3.
4. Determine the cold measurements at each location, using the appropriate gauge extension. Record the data. Figure 4 shows a measurement being taken at a typical location.
5. Determine the angles at which measurements are being made by using the inclinometer furnished with the tool set. See Figure 5. Record the data.
6. When the train is brought on line, obtain and record hot alignment data by repeating Steps 3 and 4 at each reference station.
7. Plot the data as indicated in Figure 2 to determine vertical and horizontal movements of each bearing housing.
8. Plot the hot alignment for the entire train by using the combined data from individual locations.
9. Make appropriate alignment changes as dictated by the above data.

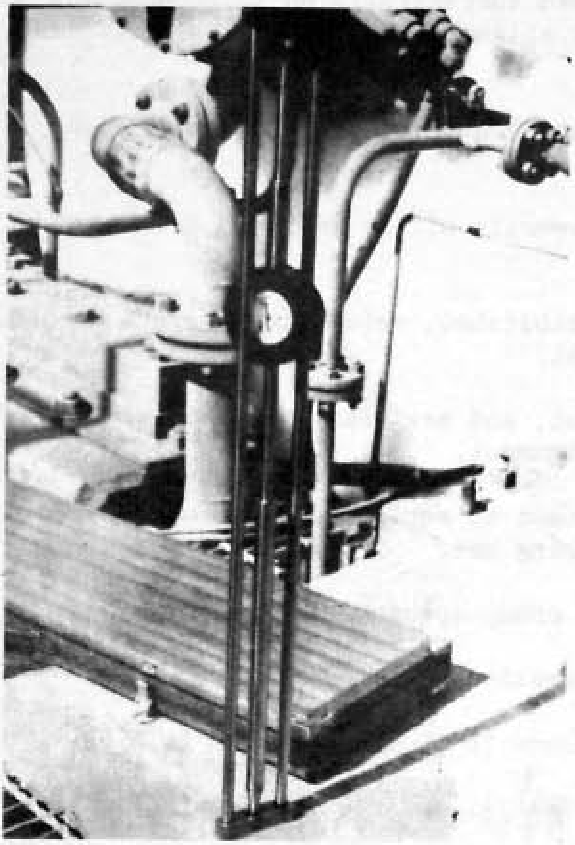

Fig. 3 - Calibration of the alignment gauge with the Invar standard.

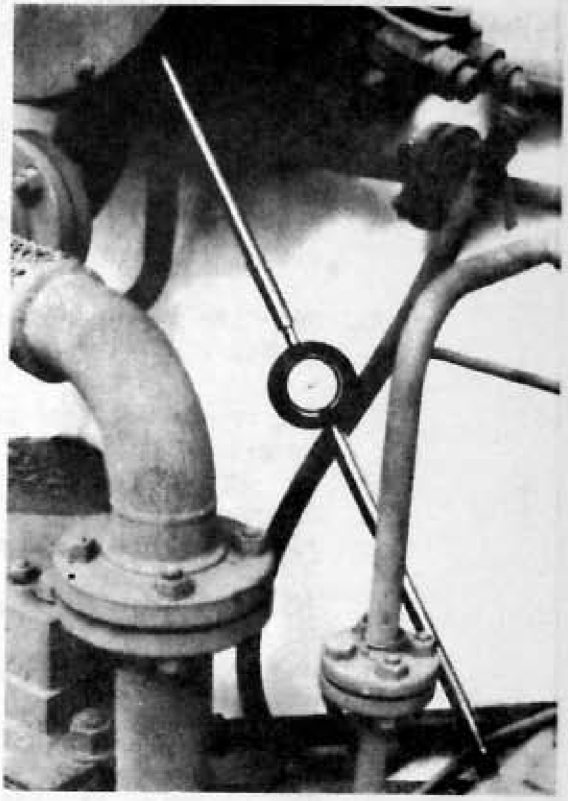

Fig. 4 - Reference measurement being taken between bearing housing and foundation.

Fig. 5 - Inclinometer for determining angle at which measurements are taken.

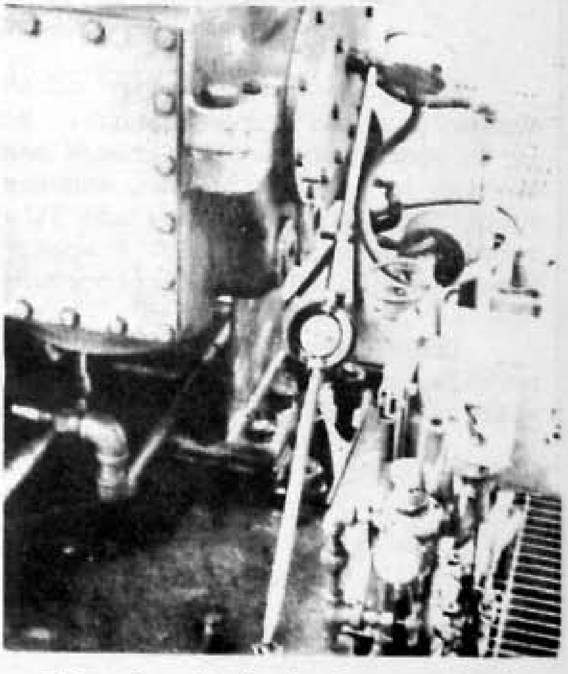

Fig. 6 - Typical placement of benchmarks on turbomachinery train.